DOCUMENT RESUME

ED 187 532 SE 030 744

AUTHOR Yeany, Russell H.; And Others
TITLE Interactive Instructional Video-Tapes, Scholastic Aptitude, Cognitive Development and Locus of Control as Variables Influencing Science Achievement.
PUB DATE Apr 80
NOTE 16p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (53rd, Boston, MA, April 11-13, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Aptitude Treatment Interaction; Biology; Cognitive Development; College Science; Educational Research; *Genetics; Higher Education; *Individual Instruction; Locus of Control; *Problem Solving; Research Reports; Science Education; *Science Instruction; *Videotape Recordings

ABSTRACT

Results are reported of a study that: (1) examined the relationships between university students' entry characteristics and achievement in biological science; and (2) assessed the effectiveness of interactive instructional video-tapes in improving science achievement. Among the variables examined as likely to predict achievement were scholastic aptitude, cognitive development, and locus of control. College biology students were assigned randomly to the experimental or control group. The experimental treatment was conducted during a genetics unit and consisted of video-tape instruction where students independently used a guided problem-solving manual while viewing the tape. The comparison group attended lecture and lab sessions but did not view the interactive tape. Results indicate that the instructional interactive video-tapes did significantly and positively influence achievement on the genetics concepts. Entry variables also proved to be significant predictors of success on all achievement measures; these and other findings are discussed in detail. (CS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED187532

U S DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Russell Yeany

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

INTERACTIVE INSTRUCTIONAL VIDEO-TAPES, SCHOLASTIC APTITUDE, COGNITIVE DEVELOPMENT AND LOCUS OF CONTROL AS VARIABLES INFLUENCING SCIENCE ACHIEVEMENT

Russell H. Yeany
Edwin A. Helseth, Jr.
William E. Barstow

Department of Science Education
University of Georgia
Athens, Georgia 30602

A Paper Presented at the Annual Meeting
of the
National Association for Research in Science Teaching

Boston, MA

April, 1980

SE 030 744

INTERACTIVE INSTRUCTIONAL VIDEO-TAPES, SCHOLASTIC APTITUDE, COGNITIVE DEVELOPMENT AND LOCUS OF CONTROL AS VARIABLES INFLUENCING SCIENCE ACHIEVEMENT

Achievement in the sciences varies greatly across university students. This variation is contributed to and is influenced by many variables. Some of these variables can be manipulated and are more or less under the control of the instructor. Others are personalogical variables which are not manipulatable but need to be identified and recognized for their influence on achievement. Bloom (1976) recently hypothesized that more learning is influenced by a student's entry characteristics than by variations in teaching. The two purposes of this study were to: (1) examine the relationships between university students' entry characteristics and achievement in biological science, and (2) to assess the effectiveness of interactive instructional video-tapes in improving science achievement. The variables which were judged most likely to be predictors of achievement because of the nature of the subject matter or instructional conditions were:

quantitative scholastic aptitude;

verbal scholastic aptitude;

level of cognitive development;

grade point average;

locus of control;

age; and,

gender.

Scholastic aptitude as measured by the SAT was selected because of its use as a university entrance examination. Its predictive power is severely limited by a restricted range. Nevertheless, the nature of the concepts and

problems being studied and the nature of the pedagogy (much reading and lecture) suggests that variations in scholastic ability may lead to or predict variations in science achievement.

Cognitive development level was selected because many science concepts are abstract or are studied through abstract models. Students who possess more formal levels of abstract reasoning ability should perform better than students with less of this ability.

Grade point average (GPA) was needed to examine the degree of relationship that exists between success in biology and general success in other university courses. Any relationship would be strictly correlational (as opposed to causal) but may point the way to identifying the causal variables.

Student locus of control (LOC) was selected as a predictor variable because of the high level of freedom and independence associated with the task of studying by university students. This freedom should favor students with an internal locus of control who perceive their desitny to be largely in their own control and believe that they possess a great deal of control over their own future. The external student views his destiny as being largely in the control of others and may not recognize regular and systematic study as a variable responsible for increased achievement.

Age of student may be related to science achievement for two reasons: (1) the older student may be more mature and possibly more goal and achievement oriented; and, (2) it is the norm that science courses (in this case biology) are taken during the freshman year. It is possible that students who enroll in these courses at a later time will have adjusted to the rigors of university study and therefore be more successful in relation to achievement.

Gender has been regularly documented as a predictor of success in science courses (Treagust, 1980). Most of the evidence to support this

conclusion has been gathered at the pre-college level. It is of interest to this study to examine the degree of continuation of this effect.

PROCEDURES

Measurement of Entry Variables

Data on the entry variables were collected through standardized tests or from student files. Locus of control was assessed by the Intellectual Achievement Responsibility Questionnaire (IAR) (see Crandall, Katkovsky, and Crandall, 1965). The KR_{21} reliability of the IAR in this study was .57.

The Test of Logical Thinking (TOLT) (Tobin and Capie, 1979) was used to measure the cognitive developmental level of the subjects. Individual scores can range from 0 to 10 on this measure: the higher scorers are judged tc be more capable of abstract thinking and learning. Scores of 0 or 1 are indicative of a concrete thinker who may be incapable of abstract reasoning. Ten percent of the subjects are in this category. It should be noted that scores at or below "3" identify an individual who may have only very limited abilities related to abstract reasoning. Thirty-eight percent of the subjects in this study are in this category. The reliability of TOLT as estimated by Cronbach's α was .84.

Age, SAT scores, gender and GPA were available in conventional university computer stored records which were accessible by a student code number while maintaining the anonymity of the student.

Measurement of Dependent Variables

Data on all achievement variables were collected with multiple-choice objective referenced tests. All items had been piloted previously. Item and test analyses were used to establish reliabilities and objective-item matching by judges was used to ensure content validity. A total of four achievement tests were administered. The first addressed the general biological topics of cell and human reproduction; the second measured

achievement in the areas of chemical structure and protein synthesis; the third measured achievement of genetics concepts and genetics problem-solving ability; and, the fourth covered cell structure and evolution. The reliability coefficients were .73, .82, .74 and .66.

Description of the Manipulated Variable

As mentioned above a purpose of this study was to assess the effectiveness of interactive instructional video-tapes in improving biology achievement. Treatment occurred prior to the third achievement test covering genetics principles and consisted of an experimental and a contrast (control) level. They are defined as follows:

Level I - Interactive Video-Instruction: Subjects in this group received ancillary instruction by viewing a 55 minute video-tape which presented problems and concepts in classical genetics. During the video lesson the student was presented with the opportunity to answer questions or work problems related to such topics as gamete formation, probability of various genotypes and phenotypes, ratios of offspring phenotypes, and Punnett Square solutions to mono- and dihybrid crosses. When a problem was presented, the lesson was delayed for a predetermined length of time for the student to answer the question or solve the problem. This procedure was facilitated by an eight page worksheet which accompanied the video-tape. The student set-up and worked problems in work-space provided in the Interactive Video-Tape Worksheet. Terms which were defined on the taped lesson were listed with a printed definition.

All students viewed the tape independently. The tapes could be stopped at any point, rewound and reviewed but there were no instructions to encourage or discourage this practice.

Level II - Comparison Group: Subjects in this group did not view the interactive tape. They attended (as did Group I) the lecture and lab sessions related to the concepts. They also had access to a science learning center where audio-tapes of the lectures could be secured as well as related audio-visual media on the topic.

Selection of Subjects

The subjects in this study were university students enrolled in a summer-term, introductory biology course at the University of Georgia. All

students met in a single lecture section three days per week and in six different lab sections one day per week. The group may be somewhat unique because an unidentifiable subset of the students were required to attend summer session on a probationary basis as a contingency for admission in fall or winter quarter. Most of these individuals possessed SAT scores below the minimum required for unrestricted admission.

During the experimental phase of the study, the subjects were randomly assigned to treatment or control situations on the basis of membership in laboratory sections Three sections were assigned to the experimental condition and three to the control. Membership in a lab section was considered to be unbiased and unrelated to treatment; therefore, the experimental unit and the unit of statistical analysis was the student.

Data Analysis

Data collected were examined by using regression analysis and general linear model procedures with SAS computer programs (Helwig and Council, 1979). Student achievement on the four tests was identified as separate dependent variables while LOC, cognitive development, gender, GPA, age, and treatment (when predicting genetics achievement) were independent variables.

RESULTS

Table 1 presents the descriptive statistics on all variables of interest. In relation to the experimental component of the study, the students who received ancillary instruction via the instructional video-tape achieved significantly more than the contrast group on the genetics concepts test. The experimental group averaged 63.8, while the contrast group averaged 60.2. Even though the means for internal and external students were as far apart as the means influenced by the treatment, locus of control was not a predictor of biology achievement on the genetic concepts, $p > .72$.

(Include Table 1 About Here)

Table 1

Descriptive Statistics for
All Variables in the Study

	N	$\bar{x}$	Standard Deviation	Minimum	Maximum
LCC	90	13.0	2.21	7	17
Cognitive Development	90	5.1	2.96	0	10
Test 1	99	58.25	14.87	35	90
Test 2	96	62.75	15.99	22.5	90
Test 3	97	61.0	9.98	15	100
Test 4	97	60.44	12.75	35	90
Age	98	20.5	3.7	17	36
SAT V	82	446.8	88.42	270	680
SAT Q	82	474.7	77.49	310	630
GPA	69	2.55	.59	.93	4.0

The level of a student's cognitive development did prove to be a significant predictor of achievement ($p < .002$) (see Table 2). The cognitive development data were entered as a continuous variable (i.e., the students were not categorized as concrete or formal: but rather, the raw score of each subject was entered in the analysis). Therefore, the statistic of interest in this case is the R^2 between cognitive development and genetics achievement which was .34. Another interesting result was the occurrence of a statistical interaction between LOC and cognitive development ($p < .06$) as measured by the achievement scores (see Figure 1). As can be observed and as mentioned above, the better logical thinkers (higher cognitive development) tended to score higher on the genetics achievement measure, but there was a differential effect dependent on the LOC of the student. The internals tended to do better than the externals as cognitive development score increased. Overall the variance sources of treatment level, LOC, cognitive development and the associated interactions accounted for sixty percent of the variance in the genetics scores with $R^2 = .596$, $F = 2.28$, and $p = .004$.

(Include Table 2 & Figure 1 About Here)

In relation to the predictive nature of the students' entry characteristics when regressed against the other three dependent variables, the results were fairly consistent. Table 3 lists the R^2 values for each of the entry characteristics and the associated achievement measure and the best two, three, and four variable models for predicting variance in achievement. It can be noted that, on all the biology achievement measures, the SAT (quantitative) score was the single best predictor of achievement with R^2 values of .42, .30 .41, and .21. The second best predictor was level of cognitive development where R^2 equals .41, .11, .34, and .10.

(Include Table 3 About Here)

TABLE 2

RESULTS OF REGRESSION ANALYSIS COMPARING
THE EFFECTS OF TREATMENT, LOCUS OF CONTROL AND
COGNITIVE DEVELOPMENT ON GENETICS ACHIEVEMENT

SOURCE	DF	SSQ	F	p
TREATMENT (T)	1	33.65	3.16	.081*
COGNITIVE DEVELOPMENT (CD)	10	353.96	3.33	.002*
LOCUS OF CONTROL (LOC)	1	1.35	0.13	.723
T X CD	9	115.59	1.21	.310
T X LOC	1	4.26	.40	.530
CD X LOC	9	188.64	1.97	.062*
T X CD X LOC	3	35.62	1.12	.351

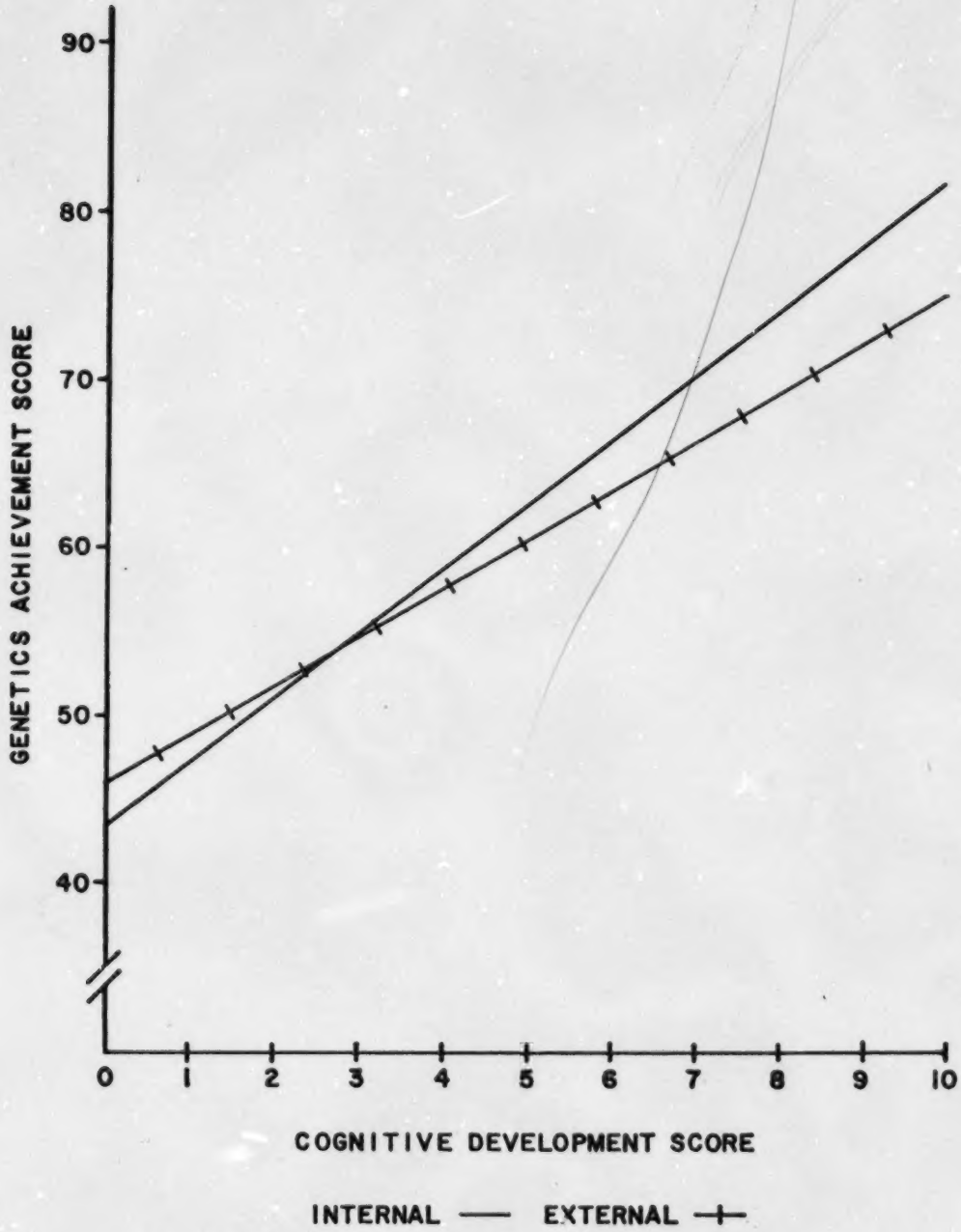

FIGURE 1. THE INTERACTION BETWEEN LOCUS OF CONTROL AND COGNITIVE DEVELOPMENT

Table 3

R^2 Values for the Independent Variables and the Predictive Two, Three and Four Variable Models

	R-Square		R-Square	Variables in Model
Test 1	0.001	SEX	0.489	SATQ GPA
	0.002	AGE	0.540	COG SATQ GPA
	0.008	LOC	0.576	COG SATQ GPA SATV
	0.147	GPA		
	0.169	SATV		
	0.409	COG		
	0.421	SATQ		
Test 2	0.001	LOC	0.325	SATQ GPA
	0.019	AGE	0.351	SATQ GPA AGE
	0.021	SATV	0.366	SATQ GPA AGE COG
	0.021	SEX		
	0.066	GPA		
	0.111	COG		
	0.297	SATQ		
Test 3	0.001	AGE	0.564	SEX SATQ
	0.025	LOC	0.579	SEX SATQ GPA
	0.029	SEX	0.590	SEX SATQ GPA COG
	0.045	SATV		
	0.125	GPA		
	0.337	COG		
	0.411	SATQ		
Test 4	0.001	LOC	0.302	GPA SATQ
	0.007	SEX	0.344	GPA SATQ AGE
	0.020	AGE	0.366	GPA SATQ AGE SEX
	0.069	SATV		
	0.101	COG		
	0.128	GPA		
	0.214	SATQ		

The best four variable model for predicting success on the first test included cognitive development, SAT (quantitative and verbal) and GPA; on the second test, SAT verbal was replaced by age; on the third, SAT verbal was replaced by gender; and, on the fourth, age, gender, SAT (quantitative) and GPA comprised the model. As can be seen, SAT (quantitative) and GPA contributed to all the models; while, cognitive development contributed to three of them. Larger models were generated and analyzed but contributed little to the predicted variance. When gender was a predictor of achievement, females significantly outscored males (males = 57.9, females = 64.3; $F = 3.95$, $p = .05$). Also of note is the fact that locus of control as measured in this study was never a significant predictor of biology achievement.

CONCLUSIONS

The results of this study indicate that interactive instructional videotapes directed to specific learner outcomes should be considered as a means of improving science achievement of university students. Although the absolute difference in scores of the treatment and comparison groups was small, the magnitude of effect in this study interpreted in terms of percent of increase in achievement gain was 6%. Considering the hierarchical structure of the knowledge and skills needed to perform genetics problems, a 6% gain in achievement is no small proportion.

The correlations between student cognitive development level and achievement was not unexpected, especially on the genetics test. These findings support the earlier results reported by Walker, Hendrix & Mertens (1979). Future investigations should attempt to find specific instructional strategies that will improve student problem-solving strategies which should in turn improve logical thinking ability in university students. Instructional strategies will have to attend to the 38% of the students not demonstrating formal operational thought processes. This has been recently suggested by

Levine and Linn (1977) and Chiapetta (1978) as well, though the percentage of non-formal students varies in each report.

The lack of any significant influence of variations in student locus of control needs further examination. This influence has been found in other studies of science achievement with younger students (Saunders & Yeany, 1979). The effects may diminish at the college level because the students overcome tendencies to behave "externally"; on the other hand, individuals who possess external characteristics which guide their behaviors may be selected out in the academic processes of high school and earlier university experiences. The lack of significant findings may also rest on our inability to measure the trait with any real precision.

The significant interaction between cognitive development and locus of control is very interesting. As was noted, the individuals with better logical thinking skills tended to achieve higher on the genetics measure. Subjects who were formal and internal scored higher than subjects who were formal and external (see Figure 1). An additional interesting fact is that there was no correlation between LOC and cognitive development. Both of these findings are supported by concurrent research being conducted by Tobin and Capie (1980). They identified a similar LOC by cognitive development interaction which was exhibited in the on-task behaviors of science students and identified a zero correlation between LOC and cognitive development.

The consistent predicting nature of the SAT quantitative is of particular interest because of recent attacks on the variable as an admission criterion. It should be noted that the restricted range phenomenon, which haunts some attempts to measure the predictive value of the SAT score, was lessened by the fact that some low scorers on the SAT exam were admitted to the summer session biology course and, therefore, were involved in the study.

Student GPA as a predictor of achievement supports the conclusions that student success is not biased or capricious. That is, students who are

academically successful tend to be so across courses and subject areas.

Regression models based on entry characteristics of students can be developed which will significantly and consistently predict achievement variance. It is also possible to influence science achievement through the use of interactive instructional video-tapes. The former results support the recent contentions of Bloom; but, the latter results show that instructional intervention can still be a significant factor in influencing science achievement.

Finally, the improvement of science instruction and the resultant learning outcomes requires continual attention. More developmental and research efforts should be applied in this area. Some attention should also be given to ensure that students of varying skills and abilities are provided with means of improving these skills and abilities. There is a possibility that solving problems similar to those in a science unit could stimulate the development of this characteristic. Also, when the primary purpose of instruction is to aid the learning of a particular set of concepts or skills, (e.g., genetics) pedagogical methods designed to help overcome deficient student entry skills (e.g., logical thinking) should be employed. In this case, less abstract and more concrete examples may be needed by some students.

REFERENCES

Bloom, B. S. Human characteristics and school learning. New York: McGraw-Hill Book Co., 1976.

Chiapetta, E. A review of Piagetian studies relevant to science instruction at the secondary and college level. Science Education, 1976, 60, 253-261.

Crandall, V. C., Katkovsky, W. & Crandall, V. J. Children's beliefs in their own control of reinforcements in intellectual academic situations. Child Development, 1965, 36, 91-109.

Helwig, J. T. & Council, K. A. (Eds.) Sas user's guide, 1979 edition. Raleigh, NC: SAS Institute, Inc., 494 pages.

Levine, D. I. & Linn, M. C. Scientific reasoning ability in adolescence: Theoretical viewpoints and educational implications. Journal of Research in Science Teaching, 1977, 14(4), 371-384.

Saunders, R. L. & Yeany, R. H. The effects of diagnosis, remediation and locus of control on achievement, retention, and attitudes of middle school science students. A paper presented at the Annual Meeting of the National Association for Research in Science Teaching, March 1979.

Tobin, K. G. & Capie, W. The relationship of formal reasoning ability and locus of control. A paper presented at the Annual Meeting of the Southeastern Association for the Education of Teachers in Science, University of Alabama, October 1979.

Tobin, K. G. & Capie, W. The development and validation of a group test of logical thinking. A paper to be presented at the Annual AERA Meeting, Boston, Massachusetts, April 1980.

Treagust, D. F. Gender-related differences of adolescents in spatial representational thought. Journal of Research in Science Teaching, 1980, 17(2), 91-97.

Walker, R. A., Hendrix, J. R. & Mertens, T. R. Written Piagetian task instrument: Its development and use. Science Education, 1979, 63(2), 211-220.